Nutritional Evaluation and Sensory Qualities of Three Selected Cookies Prepared with Honey and Fortified with Herbs and Spices

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ABSTRACT

This study looked the nutritional evaluation and sensory qualities of three types of cookies made with honey as a substitute sweetener and enhanced with various herbs and spices. A total of 60 academic staff members from food-related departments at The Federal Polytechnic, Ilaro, were purposively selected to participate in the sensory evaluation. Each participant was provided with a 9-point hedonic scale rating form to assess the cookies, and the collected data were analyzed using both descriptive and inferential statistical methods, including mean and standard deviation. Analysis of Variance (ANOVA) was conducted to determine significant differences among the cookie samples using SPSS version 23.0. Proximate analysis was performed in accordance with the 2022 standards of the Association of Official Analytical Chemists (AOAC). The Duncan Multiple Range Test was applied to further identify significant differences between samples.Sensory evaluation results showed mean ratings ranging as follows: appearance (7.66–8.15), color (7.45–7.85), taste (7.41–8.13), aroma (7.31–7.81), texture (7.51–8.20), flavor (7.26–8.16), crunchiness (7.38–7.93), crumbliness (7.53–8.05), and overall acceptability (7.76–8.45). Proximate composition analysis revealed significant differences ($p < 0.05$) among the samples, with moisture content ranging from 10.24% to 21.39%, dry matter from 78.62% to 89.76%, fat content between 16.04% and 16.81%, ash content from 1.02% to 1.67%, fiber from 0.94% to 1.37%, protein from 5.55% to 6.52%, and carbohydrate content ranging from 54.11% to 63.40%. The control cookies had higher values in most nutritional parameters, suggesting greater nutritional density, while the honey-fortified samples offered enhancements in specific sensory attributes.In conclusion, incorporating honey into cookie formulations can improve their nutritional profile without compromising consumer acceptability, supporting its use as a functional and appealing snack. Further research is recommended to optimize formulations for longer shelf life and additional health benefits.

Keywords: Cookies, Fortification, Nutritional Evaluation, proximate Composition

Introduction

Cookies are among the most widely consumed baked goods both in Nigeria and around the world, enjoyed as snacks by people of all ages. While snack foods like cookies are playing an increasingly significant role in modern diets, their nutritional potential remains largely untapped. Cookies, in particular, are popular due to their diverse flavors, crispy texture, and ease of digestion (Adeboye & Bamgbose, 2020)

As global nutritional priorities shift, there's a growing need for innovative strategies that improve the nutritional profile of everyday foods. Cookies, which are deeply rooted in snack culture across various populations, offer a valuable platform for such interventions. Despite their popularity, traditional cookies are often high in sugar and fat, offering minimal nutritional value and contributing to the prevalence of chronic illnesses when overconsumed.

Everyday food items are increasingly being targeted for nutritional enhancement, with cookies showing great promise in addressing dietary health concerns (Nogueira & Steel, 2020). Given their widespread use as snacks or meal additions, cookies are uniquely suited to support efforts to combat nutrition-related disorders. Their appealing taste, long shelf life, and convenience have driven a steady rise in both production and global consumption (Canalis, Leon, & Ribotta, 2019). Within the fast-moving consumer goods (FMCG) sector, cookies dominate the snack segment, with market figures reaching $76.385 billion in 2017 and projected to climb to $121 billion by 2021 and $164 billion by 2024, at CAGR rates of 3.7% and 5.08%, respectively (Apedaagri Exchange, 2020). With global per capita consumption reaching up to 13 kg annually, cookies are an ideal medium for fortification (Canalis, Leon, & Ribotta, 2019). They are now being used in nutrition-based strategies to address a wide range of chronic and diet-related conditions such as nutrient deficiencies, diabetes, obesity, cardiovascular disease, and cancer (Singh & Kumar, 2021).

Honey, a natural product produced by honey bees (*Apis mellifera*) from nectar, plant exudates, or insect-derived secretions, is formed through a transformation process by the bees (Becerril-Sánchez et al., 2021). Globally, honey production totals about 1,779.6 metric tons annually and is expected to see continued growth in market value by 2028 (Insights, 2022). China leads global honey production with 28%, followed by Turkey (5.9%), Iran (4.5%), the US (4.1%), and India (3.5%). Major honey importers include the US, Germany, Japan, France, the UK, Italy, and Spain, while top exporters are China, New Zealand, Argentina, Germany, Ukraine, India, and Spain (Jha, 2022). Honey is prized for its nutritional value, with a composition that varies depending on botanical and geographic origins (Ciulu et al., 2016). It primarily contains sugars (80–85%), water (15–17%), and small amounts of proteins (0.1–0.4%), along with enzymes, organic acids, vitamins, minerals, and phenolic compounds that enhance its functional and sensory properties (Baloš et al., 2020).

Food fortification—the enrichment of food with essential vitamins, minerals, and nutrients—is a long-established practice. However, its incorporation into baked goods, particularly cookies, is a relatively new trend that aligns with growing health awareness and evolving consumer preferences. This strategy not only addresses nutritional gaps by adding protein, fiber, and key micronutrients but also supports environmental sustainability through the use of agricultural by-products, thereby reducing food waste (Anderson & Smith, 2023).

This research sits at the crossroads of nutrition and food innovation, aiming to enhance the health benefits of cookies while maintaining their appeal. Fortifying cookies with honey presents both a technical and sensory challenge. Success depends not only on nutritional improvements but also on satisfying consumer expectations in terms of flavor, texture, aroma, and overall sensory experience—factors that are crucial for widespread acceptance and market success (Taylor & Williams, 2021).

Additionally, evaluating the nutritional benefits of these honey-fortified cookies goes beyond measuring nutrient levels. It also involves assessing the bioavailability of those nutrients and the real-world health effects of regular consumption.

Statement of the Problem

Despite the growing awareness of healthy eating, consumers often find it challenging to incorporate nutrient-dense foods into their diets due to preferences for convenience and taste. Cookies are a popular snack worldwide, but they are typically high in sugars and saturated fats, contributing to dietary imbalances. The challenge lies in enhancing the nutritional value of cookies without compromising their sensory appeal, which is crucial for consumer acceptance (Brown & Miller, 2019).

Objectives of the Study

The objectivesDetermine the impact of fortification on the nutritional profile of the selected cookies,evaluate the sensory qualities of the fortified cookies,compare the nutritional and sensory attributes of the fortified cookies to traditional, non-fortified ones and determine the customer preference for the samples of the cookies.

LIterature Review

Widely consumed foods are often sought for their ability to supply vital nutrients, aligning with the rising health awareness among consumers. Among these, cookies have emerged as a flexible option for addressing dietary needs and minimizing the risk of nutrition-related health problems (Nogueira & Steel, 2018). Commonly consumed as a quick snack, cookies serve as effective carriers of macronutrients such as carbohydrates and fats. Additionally, their nutritional profile can be improved by replacing refined wheat flour with protein-rich alternatives within acceptable limits (Peter et al., 2017).

Cookies present numerous possibilities for addressing health concerns linked to poor nutrition. They are widely enjoyed on their own or alongside meals, and their attractive taste, wide variety, long shelf life, and convenience have all contributed to their global popularity (Canalis et al., 2017). Within the fast-moving consumer goods industry, cookies have become a major product category (Apedaagri Exchange, 2020). In 2017, the global cookie market was valued at $76.385 billion and was projected to rise to $121 billion by 2021 and $164 billion by

2024, with estimated compound annual growth rates (CAGR) of 3.7% and 5.08%, respectively (Apedaagri Exchange, 2020). On average, cookie consumption per person worldwide is around 13 kg annually (Canalis et al., 2017).

Their widespread acceptance makes cookies an ideal vehicle for nutrient fortification. Certain cookie formulations have been incorporated into dietary strategies aimed at combating chronic conditions such as nutrient deficiencies, diabetes, obesity, heart disease, and cancer (Canalis et al., 2017; Singh & Kumar, 2017). Innovations in cookie production have led to a broader range of nutritionally enhanced products (Swapna & Jayaraj Rao, 2016). These cookies may be fortified with vitamins and minerals or supplemented with nutrient-rich ingredients. They are often tailored to suit the dietary needs of specific populations, including children, the elderly, and those with health concerns such as obesity or diabetes (Davidson, 2019).

Given their potential as functional or nutraceutical foods and their broad consumer appeal, there is growing interest in developing health-enhancing cookie varieties. Traditionally, wheat flour—due to its gluten content and ability to improve texture—has been the primary ingredient in cookie production (Oluwafemi & Seidu, 2017). In Nigeria, the use of alternative cereals and tubers has historically been limited to household use, largely because the baking sector is heavily dependent on wheat flour. To reduce this reliance, government bodies and academic institutions have promoted the use of composite flours in products like bread and cookies. Several studies have reported the successful incorporation of these flours into cookie recipes (Akusu et al., 2019; Obinna-Echem & Robinson, 2019; Ukeyima et al., 2019; Bello et al., 2020).

In Nigeria, cookies are among the most consumed baked goods after bread. They are readily available in local shops as affordable, convenient, and palatable snacks (Dauda, Abiodun, Arise, & Oyeyinka, 2018). Their appeal spans all age groups, making them a common treat for both children and adults. Cookies can be enriched with dietary fiber, protein, or other functional ingredients to boost their nutritional value—especially beneficial for children (Sulieman et al., 2019). Their ease of consumption, low cost, and digestibility make them a practical snack choice for a broad consumer base.

Typically made from wheat flour, sugar, and shortening, cookies are a popular baked snack (Xu, Zhang, Wang, & Li, 2020). Shortening—mainly composed of solid fats at room temperature—contains a high level of saturated fats. However, excessive intake of these fats has been associated with negative health effects, especially hea

rt disease (Fattore & Massa, 2018). As a result, the food industry is increasingly exploring the development of functional products that cater to consumers' growing demand for healthier, more balanced diets. Functional foods, as defined by Viera et al. (2020), are either natural or processed foods containing active compounds in sufficient quantities that offer proven health benefits

.**History of Cookies**

Cookies have a deep-rooted and fascinating history that traces back to ancient times. Early civilizations such as those in Egypt and Mesopotamia are credited with creating some of the first known cookies. These primitive cookies were typically unleavened and made from basic ingredients like flour and water, occasionally sweetened with honey or enriched with oil (Cauvain, 2015).

During the Roman era, a type of cookie called "biscotti" became popular among soldiers and travelers because of its long shelf life. These cookies were baked twice to remove moisture, making them ideal for long-distance journeys (Migliore et al., 2017). In medieval Europe, different regions began crafting their own unique cookie styles. For example, England introduced "ship's cookies," which were intentionally hard and dry to withstand long sea voyages (Hieatt & Jones, 2017).

The Industrial Revolution in the 19th century revolutionized cookie production, making them more widely accessible. Innovations in technology and mass production, including Sylvester Graham's development of a cookie-cutting machine in the U.S., greatly advanced the industry (Bennion, 2020).

The 20th century saw a surge in cookie variety, with manufacturers introducing new flavors and ingredients like chocolate, nuts, and dried fruits to cater to shifting consumer tastes (Smith, 2017). Today, cookies remain a global favorite, enjoyed as snacks, breakfast items, or alongside tea and coffee. The cookie market has expanded significantly, offering a wide array of products to meet diverse consumer demands (Apedaagri exchange, 2020).

More recently, research has focused on enhancing the nutritional value of cookies by adding essential nutrients such as vitamins and minerals. Scientists have investigated the use of functional ingredients in cookie recipes to boost their health benefits (Swapna & Jayaraj Rao, 2016).

In addition, modern baking and manufacturing techniques have enabled the creation of specialty cookies designed for specific dietary needs, such as gluten-free or reduced-sugar options (Davidson, 2019).

Materials and Methods

Srudy Area

Ilaro, established around 1650 AD by a brave hunter from Aro in Ovo, is situated at the heart of Yewa land—formerly known as Egbado land—between present-day Yewa North and Yewa South in Ogun State, Nigeria. Because of its central location, Ilaro served as the administrative and traditional capital of Yewa land from 1914 until 1976, when new local government areas were introduced.

The research was carried out at The Federal Polytechnic, Ilaro, specifically in the Department of Hospitality Management and Technology, which operates under the School of Pure and Applied Sciences. The institution was founded through Decree No. 33 on July 25, 1979, and was officially inaugurated on November 15, 1979

Materials used fot the Study

The tools utilized in the cookie-making process included measuring spoons and cups, a gas cooker, lighter, oven, mixing bowls, whisks, baking trays, parchment paper, a weighing scale, knives, and a rolling pin.
The ingredients incorporated in the recipe included butter or margarine, sugar, wheat or all-purpose flour, baking soda, baking powder, cinnamon, garlic, ginger, turmeric, eggs, vanilla flavor, honey, cocoa powder, and water for mixing.

Source uf Materials

The ingredients used in the study—such as salt, baking powder, powdered milk, eggs, and sugar—were sourced from Sayedero Market, the main local market in Ilaro, Ogun State. The necessary equipment was either provided by or obtained from the processing laboratory of the Department of Hospitality Management and Technology

Preparayion Methiod.

The cookies were made following a procedure adapted from Adegbanke, Osundahunsi, and Enujiugha (2020), with minor changes in baking time and temperature. Wheat flour was blended with other ingredients using a mixer, and the dough was kneaded for about 12 minutes—either manually or with a kneading machine—until a consistent texture was achieved. The dough was then cut and shaped into uniform sizes, baked in an oven at 250°C for 45 minutes, cooled after baking, and finally packaged in cellophane wraps. The cookies were stored at room temperature for further laboratory analysis.

Research Instrument

The primary tool for data collection was a sensory evaluation form, distributed to taste panelists after sampling the cookies. Sensory characteristics such as appearance, color, taste, aroma, texture, flavor, crunchiness, crumbliness, and overall acceptability were assessed using a 9-point hedonic scale. This scale ranged from 1 ("dislike extremely") to 9 ("like extremely").

Table 1 Recipe formulation:

Sample	Ingredients	Weight/Volume
NBC	Flour	250g
	Sugar	50g

	Butter	125g
	Baking powder	5g
	Water	60ml
	Vanilla	2.5g
GCBC	Flour	250g
	Honey	60ml
	Butter	125g
	Baking powder	5g
	Water	60ml
	Vanilla	1.5ml
	Ginger	3g
	Cinnamon	1.5g
NWC	Wheat flour	150g
	All-purpose flour	100g
	Sugar	50g
	Butter	125g
	Baking powder	5g
	Water	60ml
	Vanilla	1.5ml
GTWC	Wheat flour	150g
	All-purpose flour	100g
	Honey	60ml
	Butter	125g
	Baking powder	5g
	Water	50g
	Ginger	3g
	Turmeric	1.5g
	Vanilla	1.5ml
NCC	Flour	225g
	Sugar	50g
	Cocoa powder	25g
	Butter	125g
	Baking powder	5g
	Water	60ml
	Vanilla	1.5ml
GGCC	Flour	225g
	Honey	60ml
	Cocoa powder	25g

	Butter	125g
	Baking powder	5g
	Water	60ml
	Ginger	3g
	Garlic	1.5g
	Vanilla	1.5ml

Fig. 1: Flow Chart for theProduction

Measuring

Mixing

↓

Kneading

↓

Molding

↓

Cutting and Shaping

↓

Baking

↓

Cooling

↓

Cookie

↓

Packaging

↓

Fig. 2: Production of Normal Wheat Cookies (NWC)

Measuring

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Mixing of dry agent (wheat flour, sugar)

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Addition of water to mix

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Kneading

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Molding

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Cutting and Shaping

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Baking

↓

Cooling

↓

Cookie

↓

Packaging

Fig. 3: Flow Chart of yhe Production of Normal Chocolate Cookies (NCC)

Measuring

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Mixing of dry agent (all purpose flour, cocoa powder, baking powder, sugar)

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Addition of water to mix

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Kneading

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Molding

↓

Cutting and Shaping

↓

Baking

↓

Cooling

↓

Cookie

↓

Packaging

Fig. 4:Flow Chart of Production of Ginger Cinnamon Butter Cookies (GCBC)

Measuring

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Mixing of dry agent (flour, baking powder)

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Addition of water and honey to mix

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Addition of spices (ginger and cinnamon)

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Kneading

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Molding

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Cutting and Shaping

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Baking

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Cooling

↓

Cookie

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Packaging

Fig. 5:Flow Chart Showing the Production of Ginger Turmeric Wheat Cookies (GTWC)

Measuring

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Mixing of dry agent (wheat flour, baking powder)

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Addition of water and honey to mix

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Addition of spices (ginger and turmeric)

↓

Kneading

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Molding

↓

Cutting and Shaping

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Baking

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Cooling

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Cookie

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Packaging

Fig. 6: Flow Chart of the Production of Ginger Garlic Chocolate Cookies (GGCC)

Measuring

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Mixing of dry agent (flour, cocoa powder, baking powder)

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Addition of water and honey to mix

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Addition of spices (ginger and garlic)

↓

Kneading

↓

Molding

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Cutting and Shaping

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Baking

↓

Cooling

↓

Cookie

↓

Packaging

Procedure for Cookies production

I measured all the dry ingredirnrs/agents and poured them into the mixing bowl,everything was then mixed together, and water was added.When thoroughly mixed, I kneaded it to achieve a smooth molding consistency,it was molded smoothly and then cut into different shapes and then arranged on the baking tray.before being bakked in the oven.It was taken out to cool after some minutes and allowed to cool before being packaged.

Determination of proximate composition

Moisture Content Determination in Cookies

The moisture content in the cookie samples was assessed using the procedure outlined by AOAC (2022). An aluminum dish was first cleaned, dried, and weighed (recorded as W1). A 5 g portion of the cookie sample was placed into the dish, and the combined weight was noted as W2. The sample was then dried in a hot-air oven (300 Plus Series, Gallenkamp Oven, Widnes, Cheshire, UK) at 105 °C for 3 hours. After drying, the sample was cooled in a desiccator (CSN-SIMAX) for 30 minutes, and the final weight was recorded as W3. The moisture content was calculated using Equation (1):

$$\text{Moisture (\%)} = [(W2 - W3) / (W2 - W1)] \times 100 \quad (1)$$

Where:

- W1 = weight of the empty dish
- W2 = weight of the dish and sample before drying
- W3 = weight of the dish and sample after drying

Crude Protein Content Determination in Cookies

Crude protein content was measured using an automatic Kjeldahl analyzer (UDK 159) as per AOAC (2022). Approximately 1 g of the sample was digested using copper sulfate ($CuSO_4 \cdot 5H_2O$) and potassium sulfate (K_2SO_4) as catalysts. Digestion occurred at 420 °C in concentrated sulfuric acid (12 ml) for 60 minutes. The ammonia released was distilled and trapped in a boric acid solution (30 ml H_3BO_3), followed by titration with 0.2 N hydrochloric acid. Nitrogen content was calculated using Equation (2):

$$\% \text{ Nitrogen} = [(Vs - Vb) \times NHCl \times 14.01] / \text{Sample Weight} \quad (2)$$

Where:

- Vs = volume of acid used for the sample
- Vb = volume of acid for the blank
- NHCl = normality of HCl
- 14.01 = atomic weight of nitrogen

The protein content was determined by multiplying the nitrogen percentage by a factor of 6.25 (Equation 3):

$$\% \text{ Crude Protein} = \% \text{ Nitrogen} \times 6.25 \quad (3)$$

Crude Fat Content Determination in Cookies

Crude fat in the cookies was extracted using the Soxhlet method following AOAC (2022) guidelines. Two grams of the sample (W1) were placed in a thimble, sealed with fat-free cotton, and fitted into a Soxhlet apparatus. A pre-weighed, clean, and dry extraction flask (W2) was filled with 50 ml of petroleum ether (LobaChemie, Mumbai, India). The assembly was refluxed for 4 hours. After extraction, the solvent was evaporated, and the oil residue was dried at 70 °C for 30 minutes, cooled in a desiccator for another 30 minutes, and weighed as W3. Fat content was calculated using Equation (4):

$$\% \text{ Crude Fat} = [(W3 - W2) / W1] \times 100 \quad (4)$$

Where:

- W1 = weight of the sample
- W2 = weight of the empty extraction flask
- W3 = weight of the flask with extracted fat

Crude Fiber Content Determination in Cookies

The crude fiber content was determined using the AOAC (2022) procedure. A 1 g sample (W1) was boiled in 50 ml of 2.5% sulfuric acid for 40 minutes. The acid was drained using a vacuum pump, and the residue was rinsed with distilled water. It was then boiled in 50 ml of 2.5% sodium hydroxide for another 40 minutes. Afterward, the residue underwent sequential washing: once with 20 ml of ethanol (99.8%), twice with 20 ml of diethyl ether, and three times with 20 ml of acetone. The final residue (fiber + ash) was dried at 105 °C in a hot-air oven (DHG-9240A, China) and weighed as W2. It was then incinerated at 550 °C in a muffle furnace (Nabertherm, D-6072 Dreieich, Germany) for 3 hours, and the remaining ash was weighed as W3. The crude fiber content was calculated using Equation (5):

$$\% \text{ Crude Fiber} = [(W2 - W3) / W1] \times 100 \quad (5)$$

Where:

- W1 = initial sample weight
- W2 = weight of dried residue (fiber + ash)
- W3 = weight of incinerated residue (ash)

Ash Content Determination in Cookies

Ash content was determined via dry ashing, as per AOAC (2022). A clean, dry crucible was weighed (W1), and 5 g of the sample (W2) was placed in it and charred on a hot plate. The charred sample was incinerated in a muffle furnace (Hasthas, Servell Engineers, Chennai, India) at 550 °C for 5 hours until it turned white or gray. The crucible with ash was cooled in a desiccator and weighed as W3. Ash content was calculated using Equation (6):

$$\% \text{ Ash} = [(W3 - W1) / W2] \times 100 \quad (6)$$

Where:

- W1 = weight of the empty crucible
- W2 = weight of the sample
- W3 = weight of the crucible with ash

Carbohydrate Content Determination in Cookies

The percentage of carbohydrates was calculated by difference, subtracting the sum of moisture, ash, fat, crude fiber, and crude protein contents from 100%. All measurements were conducted in triplicate.

% Carbohydrate = 100 – (% Moisture + % Ash + % Fat + % Fiber + % Protein)

Source of Data

Data for this study were obtained from both primary and secondary sources. Primary data were collected through the use of a sensory evaluation form to gather relevant information, while secondary data were sourced from various published materials such as textbooks, journals, magazines, and online resources.

Research Population

The target population for this research consisted of academic staff from the Food and Beverage-related departments at Federal Polytechnic,Ilaro,Ogun state.

Sampling size and Techniqwes

A total of 60 taste panelists were selected using a purposive sampling technique. This method was chosen because the selected individuals possess expertise in food-related disciplines, making them suitable for the study

Validity and Reliability.

To maintain the validity and reliability of the research, appropriate data collection methods were carefully chosen and applied. The sample was deliberately selected to avoid bias, and data analysis was conducted based on a formal and pre-established plan. All procedures were free from assumptions, and the study strictly followed the corrections and guidelines provided by the supervisor

Research Design.

A qualitative survey research design was employed, involving the selection of a sample from the study population. This approach was necessary to ensure adequate and accurate responses to the research questions. Data were collected using sensory evaluation forms distributed to the chosen taste panelists.

Data Analysis

The collected data were analyzed using both descriptive and inferential statistical tools. Descriptive analysis included the use of mean, median, percentage, mean deviation, standard deviation, and correlation, all performed using SPSS (Statistical Package for the Social Sciences) version 23.0. Inferential analysis involved the use of Analysis of Variance (ANOVA) to identify significant differences in the sensory qualities of the samples. Additionally, the Duncan Multiple Range Test and Least Significant Difference (LSD) method at a 5% significance level ($P < 0.05$) were used to compare treatment means.

Results and Discussion

Sensory Evaluation

Table 2: shows the sensory properties of the samples of cookies that were produced from local raw materials sourced locally. 60 panelists were used for the study. The score ranges from 1-9 using a hedonic scale. The mean values of the samples ranged between 7.66 - 8.15, 7.45 - 7.85, 7.41–8.13, 7.31–7.81, 7.51 - 8.20, 7.26–8.16, 7.28 – 7.93, 7.53 – 8.05, and 7.76 - 8.45 in terms appearance, colour, taste, aroma, texture,flavour, crunchiness, crumbliness and overall acceptability.

From the table 2, the mean value for the appearance of the samples varied from 7.66 - 8.15 based on the sample difference. The normal sample NBC (normal butter cookies) had the highest mean value for the appearance as the appearance can be related to the frying time and raw material used for the preparation. The lowest mean value was found in sample NCC (normal chocolate cookies). It is evident that all appearance parameters of the experimental cookies were significantly different. There was no significant difference in the appearance of the samples of snacks. This result agrees with that carried out by (Ajayi, &Ojusa 2018), who assessed the sensory characteristics of snacks made from chocolate in which the influence of cocoa powder affect the appearance which is more of carbohydrate and fibre.

The mean value for the colour of the samples varied from 7.45 - 7.85 based on the sample difference. The normal sample NBC (normal butter cookies) had the highest mean value for the colour as the colour can be related to the frying time and raw material used for the preparation. The lowest mean value was found in sample GCBC (ginger cinnamon butter cookies). It is evident that all colour parameters of the experimental snacks were significantly different. This result is related to that obtained by Supatchalee, Apinya, &Apinya, (2019), who assessed the influence of raw materials and processing method on cookies which gives them different colours.

The aroma of a product is an essential parameter for the acceptance of the product. The sweetness or sourness of the product can be regarded as taste. The mean value for taste ranges from 7.31 - 7.81. The highest mean value was found in sample NBC (normal butter cookies) while the lowest mean value was found in both sample GCBC (ginger cinnamon butter cookies). Although there is no strong variation in the mean values of these samples, the differences in the aroma is related to the difference in the raw materials used for the production of these cookies. The mean value of all the normal cookies were showed differences and that of fortified cookieswere of significant difference as against was seen in a thestudy carried out by Barde, Badau, Kabir &Ndanusa, (2021) who observed no variation in the taste of different samples of snacks.

Taste, a crucial sensory attribute, significantly contributes to the overall sensory experience of food products. In this study, various fortified snacks were evaluated for their taste, and the mean values ranged from 7.41–8.13. Taste encompasses the tactile sensations perceived in the mouth, including factors such as sweetness, bitterness, sourness, tenderness, and juiciness. Observing the mean values, sample NBC (normal butter cookies) recorded the highest mean value for taste (8.13), indicating a favorable sensory experience in terms of taste. On the other hand, sample GGCC (ginger garlic chocolate cookies) had the lowest mean value for mouthfeel (7.41), suggesting a relatively less favorable tactile experience. It's noteworthy that the differences in mean values, although measurable, are not strongly pronounced. The variations in taste can be attributed to differences in formulations, ingredients, or processing methods across the various samples. Producers can use this information to refine their production processes, aiming for optimal taste characteristics that align with consumer preferences. In the context of snacks, studies on taste may draw inspiration from established methodologies in sensory analysis. For instance, previous research by Barde, Badau, Kabir, &Ndanusa (2021) emphasized the importance of taste in snacks, correlating variations in taste with differences in raw materials and processing methods. The current study on taste aligns with this broader research theme, emphasizing the significance of tactile sensations and texture in the overall sensory experience (Akinwunmi, 2018).

The mean values for texture range from 7.51–8.20, with slight variations observed among the different samples. Texture, often defined as the sensory impression of a food's consistency and mouthfeel, is a multifaceted attribute influenced by factors such as composition, processing methods, and structural properties. In the context of this study, the texture values reflect the tactile sensations perceived by panelists during the evaluation. Sample GCBC (ginger cinnamon butter cookies) stands out with the lowest mean texture value of 7.51, indicating a textural profile that may be perceived as softer or less firm compared to other samples. On the other end of the spectrum, sample NBC (normal butter cookies) has the highest mean texture value of 8.20, suggesting a firmer or denser texture. These variations in texture may be attributed to differences in ingredients, processing techniques, or formulation among the samples. The study aligns with previous research by Barde, Badau, Kabir, &Ndanusa (2021), which highlighted the significance of texture in local snacks. Additionally, the study by Li *et al.* (2019) on the sensory characteristics of baked snacks echoes the significance of texture as a key determinant of consumer preference. Li *et al.*, (2021) emphasized that the texture of baked foods is intricately linked to factors such as moisture content and cooking time, aligning with the multifaceted nature of texture explored in the current study.

The flavour scores range from 7.26 to 8.16, with NBC achieving the highest score of 8.16±1.03. The significant p-value of 0.0032 indicates that flavour is a critical factor influencing consumer preference among the samples. This finding aligns with recent studies emphasizing the importance of flavour in fortified products. For example, Ghoshal *et al.* (2020) demonstrated that incorporating soymeal into cookies enhanced their nutritional profile while also improving sensory attributes, including flavour, which was crucial for consumer acceptance. Similarly, Mahato *et al.* (2020) noted that flavour plays a pivotal role in the acceptability of fortified dairy products, indicating that sensory qualities must be prioritized in product development.

Crunchiness scores range from 7.28 to 7.93, with NCC scoring the highest at 7.93±1.35. The p-value of 0.0915 suggests no significant differences among the samples for this attribute, indicating that while crunchiness is appreciated, it may not be as decisive as flavour in overall acceptability. Recent research by Oliveira *et al.* (2021) highlights that texture attributes like crunchiness contribute to consumer enjoyment but often play a secondary role compared to flavour in fortified products. This aligns with findings from Szymandera-Buszka*et al.* (2023), which indicated that while crunchiness enhances overall enjoyment, it is not always a primary driver of consumer preference.

Crumbliness scores range from 7.53 to 8.05, with NBC again leading at 8.05±1.28. The p-value of 0.1828 indicates no significant differences among the samples for crumbliness, suggesting that this attribute may not be a critical factor in consumer choice for these cookies. Research by Kalumbi *et al.* (2023) supports this view, showing that textural attributes like crumbliness often serve as complementary qualities rather than primary determinants of overall acceptability in baked goods.

Overall acceptability scores range from 7.76 to 8.45, with NBC achieving the highest score of 8.45±0.77 and GCBC the lowest at 7.76±1.32. The significant p-value of 0.0055 indicates notable differences in overall acceptability among samples, reinforcing the notion that consumers have distinct preferences based on a combination of sensory attributes rather than isolated characteristics alone (Ghoshal *et al.*, 2020). This aligns with recent literature emphasizing that overall acceptability is influenced more by an interplay of attributes than by any single element (Tao & Cho, 2022).

Table 2: Sensory evaluation of cookies

Samples	Sample formulation	Appearance	Colour	Taste	Aroma	Texture	Flavour	Crunchiness	Crumbliness	Over all Acceptability
NBC	Normal	8.15±1.05[a]	7.85±1.10[a]	8.13±0.99[a]	7.81±1.44[a]	8.20±1.07[a]	8.16±1.03[a]	7.93±1.35[a]	8.05±1.28[a]	8.45±0.77[a]
NCC	Normal	7.66±1.35[a]	7.66±1.37[a]	7.78±1.35[ab]	7.75±1.24[a]	7.85±1.11[a]	7.61±1.19ab	7.78±1.25[a]	7.91±1.38[a]	8.25±0.95[ab]
NWC	Normal	7.95±1.20[a]	7.78±1.09[a]	7.70±1.13[ab]	7.78±1.12[a]	7.78±1.22[a]	7.78±1.14[ab]	7.70±1.17[a]	7.85±1.22[a]	8.21±0.98[ab]
GTWC	G2:T1	7.84±1.23[a]	7.93±1.11[a]	7.50±1.38[ab]	7.61±1.34[a]	7.81±1.25[a]	7.45±1.33[b]	7.73±1.06[a]	7.55±1.38[a]	8.00±1.22[ab]
GCBC	G2:C1	7.83±1.32[a]	7.45±1.33[a]	7.50±1.42[ab]	7.31±1.46[a]	7.51±1.65[a]	7.26±1.58[b]	7.43±1.56[a]	7.56±1.54[a]	7.76±1.32[b]
GGCC	G2:G1	7.70±1.31[a]	7.53±1.33[a]	7.41±1.42[b]	7.45±1.37[a]	7.53±1.47[a]	7.41±1.50[b]	7.28±1.61[a]	7.53±1.58[a]	7.81±1.41[b]
p-value		0.3062	0.2425	0.0302	0.2353	0.0570	0.0032	0.0915	0.1828	0.0055

Source: Field Survey, 2025

Values are presented as mean with standard deviations of responses from panelists (n=60). Means with same or no letters within the same column are not significantly different (p>0.05), separated using the Tukey's HSD test at 5% confidence interval.

Key:

NBC: Normal Butter Cookies

NCC: Normal Chocolate Cookies

NWC: Normal Wheat Cookies

GTWC: Ginger Turmeric Wheat Cookies

GCBC: Ginger Cinnamon Butter Cookies

GGCC: Ginger Garlic Chocolate Cookies

Proximate Composition

Table 3: shows the moisture content of cookies samples. The moisture content displayed a considerable range from 10.24% in NCC to 21.39% in GGCC, indicating significant variability among the samples. The notably lower moisture content in NCC suggests a formulation that may prioritize shelf stability and texture, while the higher moisture levels in the other cookies likely reflect the inclusion of ingredients that retain more water.The p-value of < 0.0001 confirms that the differences in moisture content among the samples are statistically significant, suggesting that these variations are not due to random chance but rather reflect the unique formulations of each cookie type. This finding is consistent with research conducted by Thompson (2023), which examined gluten-free cookies and found that moisture content significantly impacted cookie spread and consumer acceptability. In that study, cookies made with alternative ingredients retained different moisture levels, affecting their overall quality.

Moreover, a study by Adebayo *et al.* (2018)highlighted those cookies made from composite flours exhibited varying moisture contents, which influenced their sensory qualities and shelf life. The lower moisture content in NCC suggests a formulation that may prioritize shelf stability and texture, while the higher moisture levels in GTWC, NWC, NBC, GCBC, and GGCC likely indicate the inclusion of ingredients that retain more water.The findings also align with insights from a study on cookies produced using okara and other flours, which emphasized the importance of moisture management for achieving desirable sensory attributes (Adebayo *et al.*, 2018). High moisture content can lead to a shorter shelf life due to increased susceptibility to microbial growth, as noted by Jemziya (2017). This is particularly relevant for cookies like GGCC, which has the highest moisture content at 21.39%.

The dry matter content varies significantly, ranging from 89.76% in NCC to 78.62% in GGCC. This substantial difference highlights how various formulations and ingredients can impact the dry matter levels of baked products.The p-value of < 0.0001 indicates that the differences in dry matter content among the samples are statistically significant. This suggests that these variations are not random but rather reflect the specific ingredients and formulations used in each cookie type. This finding is consistent with research by Adebayo *et al.* (2018), which examined cookies made from composite flours and found that dry matter content was closely related to the type of flour used, affecting both nutritional quality and sensory properties.In particular, the notably higher dry matter content in NCC suggests a formulation that may contain fewer moisture-retaining ingredients compared to the other samples. Conversely, the lower dry matter levels in GTWC, NWC, NBC, GCBC, and GGCC indicate a higher moisture content or the presence of ingredients that contribute to lower dry matter, such as added fruits or syrups.Research by Thompson (2023) further supports these findings, demonstrating that cookies made with alternative ingredients often exhibit varying dry matter levels, which can influence texture and consumer acceptability. The study emphasized that managing dry matter is crucial for achieving desired sensory attributes in baked goods.Additionally, a study by Jemziya (2017) noted that higher dry matter content generally correlates with better shelf stability and longer shelf life for baked products. This is particularly relevant for manufacturers aiming to enhance the nutritional profile of fortified cookies while maintaining desirable sensory qualities.

The fat content varies significantly, ranging from 16.81% in NCC to 16.04% in GGCC. This variation underscores how different formulations and ingredient choices can influence the fat levels in baked products.The p-value of < 0.0001 indicates that the differences in fat content among the samples are statistically significant, meaning these variations are likely due to the specific ingredients used rather than random chance. This finding is consistent with research conducted by Ghoshal *et al.* (2020), which developed soymeal-fortified cookies and found that fat content was affected by the type of flour used in the formulation. Their study highlighted that incorporating protein-rich ingredients can lead to a decrease in fat content while enhancing nutritional value.In contrast, Thompson (2023) examined gluten-free sugar cookies made with kudzu starch as a partial fat replacement and found that fat content directly influenced cookie spread and consumer acceptability. This suggests that managing fat levels is crucial for achieving desirable sensory qualities while also meeting nutritional goals.Furthermore, research by Okwu *et al.* (2022) on cookies enriched with orange-fleshed sweet potato indicated that varying fat levels could significantly impact both sensory properties and consumer preferences. Their findings suggest that lower fat content can enhance the overall acceptability of baked goods, particularly when balanced with other nutritional enhancements.

The ash content varies significantly, ranging from 1.67% in NCC to 1.02% in GGCC. This variation highlights how different formulations and ingredient choices can influence the mineral content of baked products.The p-value of < 0.0001 indicates that the differences in ash content among the samples are statistically significant, suggesting that these variations are likely due to the specific ingredients used rather than random chance. This finding is consistent with research by Tagliani *et al.* (2023), which examined cookies enriched with grape pomace and found that the addition of such by-products increased the ash content significantly, indicating a higher mineral presence compared to control cookies.Furthermore, a study by Ghoshal *et al.* (2020) on soymeal-fortified cookies reported similar findings, where fortification with nutrient-dense ingredients led to an increase in ash content. Their research showed that cookies made with soy flour exhibited higher levels of essential minerals, which are beneficial for improving the nutritional profile of baked goods.In addition, research by Igbabul*et al.* (2019) demonstrated that cookies produced from blends of maize and millet had increased ash content due to the incorporation of millet, which is known for its high mineral content. The study emphasized that enhancing ash levels in cookies not only improves their nutritional value but also contributes positively to consumer health.Moreover, a study by Kaczmarek *et al.* (2021) investigated the effects of adding fruit and vegetable by-products to cookies and noted that such fortifications often resulted in increased ash content due to the rich mineral profiles of these ingredients. This aligns with the observed trend in the current study where cookies with varying formulations show significant differences in ash levels.

The fiber content varies significantly, ranging from 1.37% in NCC to 0.94% in GGCC. This variation highlights how different formulations and ingredient choices can influence the dietary fiber levels in baked products.The p-value of < 0.0001 indicates that the differences in fiber content among the samples are statistically significant, suggesting that these variations are likely due to the specific ingredients used rather than random chance. This finding is consistent with research by Ahure, *et al.* (2020), which investigated cookies produced from blends of wheat, almond, and carrot flour. Their study found that incorporating alternative flours significantly increased dietary fiber content, enhancing the nutritional profile of the cookies.Additionally, a study by Ogunjobi and Ogunwolu (2010) on cookies enriched with various fiber sources reported that increasing the proportion of high-fiber ingredients led to a notable rise in dietary fiber levels. The authors emphasized that such fortifications not only improve nutritional value but also contribute positively to digestive health. A study carried out by (Igbabul *et al.* (2019) further supports these findings, showing that cookies produced from blends of maize and millet had increased fiber content due to the incorporation of millet, which is known for its high dietary fiber levels. Their study highlighted that enhancing fiber content not only improves nutritional value but also supports gastrointestinal health.

The fat content results ofcookies samples. This variation underscores how different formulations and ingredient choices can influence the protein levels in baked products.The p-value of < 0.0001 indicates that the differences in protein content among the samples are statistically significant, suggesting that these variations are likely attributable to the specific ingredients used rather than random chance. This finding is consistent with research by Ghoshal *et al.* (2020), which developed soymeal-fortified cookies and found that incorporating soy flour significantly increased the protein content of the cookies. Their study emphasized that using defatted soy flour, rich in essential amino acids, can enhance the nutritional profile of baked goods.Moreover, a study conducted by Okpala and Okoli (2021) demonstrated that cookies fortified with brewer's spent grain (BSG) showed significant increases in protein content compared to control cookies made solely from wheat flour. The addition of BSG not only improved the protein levels but also enhanced other nutritional aspects such as fiber and ash content, making these cookies more beneficial for health.

Table 3: Proximate composition of Cookies samples

Samples	Moisture content	Dry matter	Fat	Ash	Fibre	Protein	Carbohydrate
NCC	10.24±0.02f	89.76±0.01a	16.81±0.01a	1.67±0.01a	1.37±0.01a	6.52±0.01a	63.40±0.01a
GTWC	20.76±0.01b	79.79±0.01b	16.69±0.02b	1.41±0.02b	1.25±0.01b	6.31±0.01b	55.12±0.01c
NWC	20.22±0.02e	79.80±0.01b	16.66±0.02bc	1.41±0.02b	1.25±0.01b	6.32±0.01b	54.11±0.01f
NBC	20.35±0.01d	79.66±0.03c	16.60±0.03c	1.40±0.03b	1.11±0.01c	6.13±0.02c	54.43±0.01e
GCBC	20.67±0.02c	79.33±0.01d	16.41±0.01d	1.23±0.04c	1.03±0.01d	6.02±0.02d	54.66±0.02d
GGCC	21.39±0.01a	78.62±0.01e	16.04±0.01e	1.02±0.01d	0.94±0.01e	5.55±0.01e	55.26±0.27b
p-values	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Source: Field Survey, 2025

Values are presented as mean with standard deviations of replicate determinations (n=2). Means with same letter within the same column are not significantly different (*p*>0.05), separated using the Tukey's HSD test at 5% confidence interval.

Key:

NBC: Normal Butter Cookies
NCC: Normal Chocolate Cookies
NWC: Normal Wheat Cookies
GTWC: Ginger Turmeric Wheat Cookies
GCBC: Ginger Cinnamon Butter Cookies
GGCC: Ginger Garlic Chocolate Cookies

Conclusion

The findings from this study indicate that normal butter cookies produced had the highest value in the appearance, taste, aroma, texture, flavour, crunchiness, crumbliness, and over allacceptability except in colour. The proximate evaluation result indicates that sample of normal butter cookies had the highest mean value in all the proximate properties across the table except the moisture content showing that the normal butter cookies is more nutritional than all other samples of cookies. The low moisture content of the normal butter cookies is an indication of longer shelf-life.

Recommendations

Based on the results of the study, the following suggestions are proposed:

i. To enhance both the nutritional value and consumer appeal, producers should consider fortifying cookies. This approach could help broaden consumer interest by catering to diverse preferences.

ii. Although traditional butter cookies offer superior nutritional benefits, their sensory qualities—particularly overall acceptability, appearance, and color—should be improved. This could involve optimizing production techniques or incorporating suitable additives that do not compromise their nutritional integrity.

iii. Ongoing research into advanced cookie production methods and the use of beneficial additives is highly recommended.

iv. Future studies should explore the mineral content of cookies, particularly focusing on essential micronutrients such as zinc and magnesium, to expand existing research on cookie composition.

v. Additional investigations are needed to assess the functional properties of cookie samples. This includes analyzing the raw materials in terms of pasting characteristics, mineral content, nutrient bioavailability, and microbial safety.

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